CLAIMS

1. A scanning observation apparatus comprising:

a low-coherence light source;

light separating means for separating light emitted from the low-coherence light source into an observation light optical path and a reference light optical path;

optical path length variation means provided on at least one of the observation light optical path and reference light optical path;

converging means provided on the other end side of the observation light optical path as to the light separating means;

a light-receiving optical system for photo-reception of light, emitted from the converging means and irradiated on an object of measurement, which has been reflected or scattered;

an observation light return optical path for transmitting light received by the light-receiving optical system; light joining means for joining observation light return optical path and the reference light optical path; and light detecting means for converting light from light joining means into electric signals;

image-forming means for generating an image of the object to be observed from the signals detected by the light detecting means;

display means for displaying an image;

light transmission state changing means provided on the reference light optical path and having optical scanning means for scanning light on the object to be measured, for changing the interference state at the light joining means;

a reference member capable of changing the distance as to the converging means at a position where irradiation of light is received from the converging means;

focal position detecting means for determining a position as to the reference member and the converging means, based on signals detected by the focus light detecting means, in a state wherein the light transmission state changing means are operated and the transmission efficiency of the reference light optical path is reduced; and

optical path length adjusting means for operating the optical path length variation means based on signals detected by the light detecting means, in a state wherein the light transmission state changing means are operated and interference occurs at the light joining means, such that the optical length of the optical path from the light separating means and passing through the observation light optical path, the converging means, the reference member position determined by the focal position detecting means, the light-receiving optical system, the observation light return optical path, and the light joining means, and that

of the reference optical path, generally accord.

2. A scanning observation apparatus according to Claim 1, wherein signals detected with the light detecting means used by the focal position detecting means are light intensity or contrast information.

3. A scanning observation apparatus according to Claim 1, wherein signals detected with the light detecting means used by the optical path length adjusting means are light intensity or detection information.

4. A scanning observation apparatus according to Claim 1, wherein the focal position detecting means are means for adjusting the position of the reference member as to the converging means at a position where the value of the intensity information or the contrast information of light detected with the light detecting means is maximal.

5. A scanning observation apparatus according to Claim 4, wherein the optical path length adjusting means are means for adjusting the optical path variation means such that the value of the intensity information or the contrast information of light detected with the light detecting means is maximal.

6. A scanning observation apparatus according to Claim 1, wherein the focal position detecting means are means for generally according the surface position of the reference member for the focal position of the converging means.

7. A scanning observation apparatus according to Claim 1, wherein the focal position detecting means are means for according the surface position of the reference member for the focal position of the converging means within the depth of field of the converging means.

8. A scanning observation apparatus according to Claim 1, wherein, with the optical length of the optical path from the light separating means and passing through the observation light optical path, the converging means, the reference member position determined by the focal position detecting means, the light-receiving optical system, the observation light return optical path, and the light joining means, as optical path A in a state wherein the light transmission state changing means are operated and interference occurs at the light joining means, the optical path length adjusting means operate the optical path variation means based on signals detected at the light detecting means, and the difference between the optical path A and the optical length of the reference light optical path is compacted into a range narrower than the longer of the depth of field of the converging means and the coherence length of the low-coherence light source.

9. A scanning observation apparatus according to Claim 1, wherein the light transmission state changing means are movable shielding or light reducing means.

10. A scanning observation apparatus according to Claim 1, wherein the light transmission state changing means are means for shifting the optical axis of the reference light optical path.

11. A scanning observation apparatus according to Claim 1, further comprising a probe portion configured such that the observation light optical path, the converging means, the light-receiving optical system, and at least part of the observation light return optical path, are detachable from the light separating means.

12. A scanning observation apparatus according to Claim 1, further comprising a probe wherein at least a part of at least one of the observation light optical path, the converging means, the light-receiving optical system, and the observation light return optical path, is configured of flexible light transmitting means.

13. A scanning observation apparatus according to Claim 11, wherein the probe portion is provided within an endoscope.

14. A scanning observation apparatus according to Claim 11, wherein the probe portion is insertable through an endoscope.

15. A scanning observation apparatus according to Claim 1, wherein the converging means and the light-receiving optical system are the same.

16. A scanning observation apparatus according to Claim 1, wherein the converging means and the light-receiving optical system are the same, and generally form a confocal optical system.

17. A scanning observation apparatus according to Claim 1, wherein the reference member is provided on an adjusting jig detachably provided on at least one of the converging means and the light-receiving optical system.

18. A scanning observation apparatus according to Claim 17, wherein the adjusting jig has distance changing means for changing the distance between the converging means, and the light-receiving optical system and the reflection scattering member.

19. A scanning observation apparatus according to Claim 18, wherein the distance changing means are provided with an actuator and are operated with the focal position detecting means.

20. A scanning observation apparatus according to Claim 11, wherein the reference member is integrally configured with the probe portion, and comprises depth scanning means for changing the distance between the reference member and the converging means.

21. A scanning observation apparatus according to Claim 20, wherein the depth scanning means are provided with an actuator and are operated with the focal position detecting

means.

22. A scanning observation apparatus according to Claim 1, wherein the light detecting means have at least two or more outputs.

23. A method for setting a scanning observation apparatus comprising:

a low-coherence light source;

light separating means for separating light emitted from the low-coherence light source into an observation light optical path and a reference light optical path;

optical path length variation means provided on at least one of the observation light optical path and reference light optical path;

converging means provided on the other end side of the observation light optical path as to the separating means;

a light-receiving optical system for photo-reception of light, emitted from the converging means and irradiated on an object of measurement, which has been reflected or scattered;

light joining means for joining an observation light return optical path for transmitting light received by the light-receiving optical system, the observation light return optical path, and the reference light optical path;

light detecting means for converting light from the light joining means into electric signals;

image-forming means for generating an image of the object to be observed from the signals detected by the light detecting means;

display means for displaying an image; and

optical scanning means for scanning light on the object to be measured;

the method comprising:

a first step for reducing the transmission efficiency of the reference light optical path;

a second step for making reference to the output of the light detecting means with regard to the reference member, and positioning the reference member near the focal position of the converging means;

a third step for restoring the transmission efficiency of the reference light optical path; and

a fourth step wherein, with the optical length of the optical path from the light separating means and passing through the observation light optical path, the converging means, the reference member position determined by the focus position detecting means, the light-receiving optical system, the observation light return optical path, and the light joining means, as optical path A in a state wherein positioning of the reference member is determined in the second step, signals detected by the light detecting means are referred to, the optical path variation means are

operated, and the optical length of the optical path A and the reference light optical path are generally accorded.

24. A scanning observation apparatus comprising:

an optical probe inserted into a body cavity;

a light source for generating light for irradiating light upon a subject portion;

converging means for converging the light and irradiating upon the subject portion;

optical scanning means for scanning the subject portion with the converging means in a direction orthogonal to the optical axis direction of the converging means;

focal point moving means enabling changing the position of a focal point converged on the subject portion along the optical axis direction of the converging means;

light detecting means for detecting return light from the subject portion; and

flexible driving force transmitting means provided in the axial direction of the optical probe;

wherein the focal point moving means are driven by the driving force transmitting means.

25. A scanning observation apparatus according to Claim 24, wherein the converging means, the optical scanning means, and the focal point moving means, are provided in a tip hard portion comprising optically-visible light irradiating means and visible light imaging means, and the tip hard portion of

an endoscope having a flexible insertion portion.

26. A scanning observation apparatus comprising:

an optical probe inserted into a body cavity;

a light source for generating light for irradiating light upon a subject portion;

converging means for converging the light and irradiating upon the subject portion;

optical scanning means for scanning the subject portion with the converging means in a direction orthogonal to the optical axis direction of the converging means;

focal point moving means enabling changing the position of a focal point converged on the subject portion along the optical axis direction of the converging means; and

light detecting means for detecting return light from the subject portion;

wherein the focal point moving means comprise a movable mirror disposed between the converging means and the subject.

27. A scanning observation apparatus comprising:

an optical probe inserted into a body cavity;

a light source for generating low-coherence light for irradiating light upon a subject portion;

converging means for converging the light and irradiating upon the subject portion;

optical scanning means for scanning the subject portion with the converging means in a direction orthogonal to the

optical axis direction of the converging means;

focal point moving means enabling changing the position of a focal point converged on the subject portion along the optical axis direction of the converging means;

light detecting means for detecting return light from the subject portion; and

refractive index rectifying means capable of changing the spacing between the converging means and the subject, disposed between the converging means and the subject, having a refractive index rectifying substance which has generally the same refractive index as that of the subject.

28. A scanning observation apparatus comprising:

an optical probe inserted into a body cavity;

a light source for generating light for irradiating light upon a subject portion;

converging means for converging the light and irradiating upon the subject portion;

optical scanning means for scanning focal point converged on the subject portion with the converging means in a direction orthogonal to the optical axis direction of the converging means;

focal point moving means enabling changing the position of a focal point converged on the subject portion along the optical axis direction of the converging means; and

light detecting means for detecting return light from

the subject portion;

wherein the focal point moving means are driven by flexible driving force transmitting means provided in the axial direction of the optical probe.

29. A scanning observation apparatus according to Claim 28, wherein the flexible driving force transmitting means transmit the directly-driven advancement and retreating.

30. A scanning observation apparatus according to Claim 27, wherein a displacement conversion mechanism is disposed between the flexible driving force transmitting means and focal point moving means.

31. A scanning observation apparatus according to Claim 28, wherein the flexible driving force transmitting means transmit rotation.

32. A scanning observation apparatus comprising:

an optical probe inserted into a body cavity;

a light source for generating light for irradiating light upon a subject portion;

converging means for converging the light and irradiating upon the subject portion;

optical scanning means for scanning a focal point converged on the subject portion with the converging means in a direction orthogonal to the optical axis direction of the converging means;

focal point moving means enabling changing the position

of a focal point converged on the subject portion along the optical axis direction of the converging means; and

light detecting means for detecting return light from the subject portion;

wherein a movable mirror is disposed between the converging means and subject, and the focal point moving means have the movable mirror.

33. A scanning observation apparatus according to Claim 32, wherein the movable mirror is configured of a curved face, and the focal position moves generally linearly by moving of the movable mirror.

34. A scanning observation apparatus according to Claim 32, wherein the movable mirror is provided so as to oscillate in a direction perpendicular to the general axial direction of the probe, and wherein the optical scanning direction of the scanning means is generally perpendicular to the axial direction of the probe.

35. An optical scanning observation apparatus comprising:

an optical probe inserted into a body cavity;

a light source for generating light for irradiating light upon a subject portion;

converging means for converging the light and irradiating upon the subject portion;

optical scanning means for scanning a focal point converged on the subject portion with the converging means

in a direction orthogonal to the optical axis direction of the converging means;

focal point moving means enabling changing the position of a focal point converged on the subject portion along the optical axis direction of the converging means; and

light detecting means for detecting return light from the subject portion;

the scanning observation apparatus comprising:

scan position detecting means for the position of a converging point scanned by the optical scanning means;

signal processing means for processing signals obtained from the light detecting means; and

image generating means for generating a two-dimensional or higher-dimensional image from signals from the scan position detecting means and signals from the signal processing means.

36. A scanning observation apparatus according to Claim 35, further comprising focal position detecting means for detecting the moving position of the converging point by the focal point moving means, and image generating means for generating a two-dimensional or higher-dimensional tomographic image of depth-wise direction from signals from the scan position detecting means and signals from the signal processing means.

37. A scanning observation apparatus according to Claim

35, further comprising optical fiber for introducing light from the light source to the converging means;

and comprising separating means for separating the return light from the subject portion from the optical path from the light source, wherein light separated by the separating means is detected by the light detecting means;

wherein the optical fiber and the converging means are confocal or near-confocal.

38. A scanning observation apparatus according to Claim 35, further comprising:

a low-coherence light source which is the light source;

separating means for separating light from the light source into observation light to the converging means and reference light; and

joining means for joining return light from the subject portion and the reference light so as to effect interference;

wherein the light detecting means detect light from the joining means;

and wherein interference signals from signals obtained by the light detecting means are extracted by the signal processing means.

39. A scanning observation apparatus comprising:

an optical probe inserted into a body cavity;

a low-coherence light source;

converging means for converging the light and irradiating upon the subject portion;

separating means for separating light from the light source into observation light to the converging means and reference light;

optical scanning means for scanning the focal point converged on the subject portion side with the converging means in a direction orthogonal to the optical axis direction of the converging means;

focal point moving means enabling changing the position of a focal point converged on the subject portion side along the optical axis direction of the converging means; and

joining means for joining return light from the subject portion and the reference light so as to effect interference; and

light detecting means for detecting return light from the joining means;

wherein the scanning observation apparatus further includes refractive index rectifying means between the converging means and the subject, the refractive index rectifying means having a refractive index rectifying substance which has substantially the same refractive index as that of the transparent and flexible subject capable of changing the spacing between the converging means and the subject.

40. A scanning observation apparatus comprising:

an optical probe inserted into a body cavity;

a light source for generating light for irradiating light upon a subject portion;

converging means for converging the light and irradiating upon the subject portion;

optical scanning means for scanning the subject portion with the converging means in a direction orthogonal to the optical axis direction of the converging means;

light detecting means for detecting return light from the subject portion; and

optical scanning probe tip position moving means for enabling changing of the focal position converged on the subject portion along at least one direction of the optical axis direction of the converging means or the direction orthogonal to the optical axis direction, by moving the optical scanning probe tip.

41. A scanning observation apparatus according to Claim 40, further comprising reference position fixing means for moving means which fix the reference position of moving means of the optical scanning probe tip position as to the inside of a tube through which the optical scanning probe has been passed through.

42. A scanning observation apparatus according to Claim 40, further comprising driving force transmitting means for

transmitting driving force to the moving means of the optical scanning probe tip position.

43. A scanning observation apparatus according to Claim 40, wherein the moving means of the optical scanning probe tip position comprise a moving enabling unit for movably holding the optical scanning probe tip position, and driving means for driving the moving enabling unit.

44. A scanning observation apparatus according to Claim 42, wherein the driving force transmitting means are fluid sealed in the optical scanning probe;

and wherein the moving means of the optical scanning probe tip position are a watertight elastic member;

and wherein the driving means are a variation mechanism for the pressure of the fluid sealed in the elastic member;

and wherein the vicinity of the tip portion of the optical scanning probe is moved in the longitudinal direction of the optical scanning probe by controlling the pressure of the driving force transmitting means with the diving means so as to extend and shrink the moving means of the optical scanning probe tip position.

45. A scanning observation apparatus according to Claim 43, wherein the driving force transmitting means are fluid sealed in the optical scanning probe;

wherein the moving means of the optical scanning probe tip position are a plurality of balloons each connected to a

watertight elastic member having a plurality of lumens, and wherein the driving means are a variation mechanism for the pressure of the fluid sealed in the elastic member;

and wherein with the driving means, an optional balloon is expanded by controlling the pressure of each of the balloons connected to the plurality of lumens, so as to move in at least one direction of the longitudinal direction of the optical scanning probe and the orthogonal direction.

46. A scanning observation apparatus according to Claim 40, wherein the converging means are in a direction parallel to the longitudinal direction of the probe;

and wherein, in the event of the moving means of the optical scanning probe tip position moving the probe in the longitudinal direction, scanning is performed in the depth-wise direction from the surface of the subject portion;

and wherein, in the event of the moving means of the optical scanning probe tip position moving the probe orthogonal to the longitudinal direction of the probe, scanning is performed along the surface of the subject portion.

47. A scanning observation apparatus according to Claim 40, wherein the converging means are in a direction orthogonal to the longitudinal direction of the probe;

and wherein, in the event of the moving means of the optical scanning probe tip position moving the probe in the

longitudinal direction, scanning is performed along the surface of the subject portion;

and wherein, in the event of the moving means of the optical scanning probe tip position moving the probe orthogonal to the longitudinal direction of the probe, scanning is performed in the depth-wise direction from the surface of the subject portion.

48. A scanning observation apparatus comprising:

an optical probe inserted through a channel in an endoscope;

a light source for generating light for irradiating light upon a subject portion;

converging means for converging the light and irradiating upon the subject portion;

optical scanning means for scanning the subject portion with the converging means in a direction orthogonal to the optical axis direction of the converging means;

light detecting means for detecting return light from the subject portion; and

and endoscope inserted into a body cavity;

wherein optical scanning probe tip position moving means, for enabling changing of the focal position converged on the subject portion along at least one direction of the optical axis direction of the converging means or the direction orthogonal to the optical axis direction by moving

the optical scanning probe tip, are provided to the endoscope.

49. A scanning observation apparatus according to Claim 48, further comprising reference position fixing means for moving means which fix the reference position of moving means of the optical scanning probe tip position as to the vicinity of the tip within the endoscope channel through which the optical scanning probe has been passed through.

50. A scanning observation apparatus according to Claim 48, further comprising driving force transmitting means for transmitting driving force to the moving means of the optical scanning probe tip position, and driving means for driving the moving means of the optical scanning probe tip position.